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Annals of Biological Research, 2013, 4 (1):170-176
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

The effect of different levels of Superabsorbent on efficiency of the Photosynthetic matter the remobilization and portion of remobilization in seed yield of corn (*Zea mays* L.) under drought stress

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ABSTRACT

This experiment was conducted to study the effects of superabsorbent on the performance on yield, yield components and some of physiological characteristic of corn under drought stress conditions. Experimental design was split plot in form of randomize complete block design (RCBD) with three replication in Birjand Azad university farm. Irrigation treatments with three levels (100, 70 and 40 percent of plant water needs) where chosen as the main plot and the Superabsorbent with four levels (0, 35, 70 and 105 kg per hectare) where chosen subplots. Result show that the highest seed yield (579.58 g/m2) was related to the optimum irrigation treatment (100 percent plant waters need) and 105 kg Superabsorbent per hectare and the least seed yield (8.17 g/ m2) was related to intensive stress treatment (40 percent plant waters need) and the control treatment (lack of Superabsorbent). Drought stress had a positive and significant effect on the amount and efficiency of the Photosynthetic matter the remobilization and also on the portion of remobilization in seed yield, but the Superabsorbent with a positive effect on the physiological characters of corn had a negative and significant effect on the amount and efficiency of Photosynthetic matter remobilization and the portion of remobilization in seed yield.

Keywords: Leaf area index, Leaf area duration, Photosynthetic matter, remobilization, Superabsorbent.

INTRODUCTION

Aridity is one of the main worldwide issues in growing crops, especially in arid and semi-arid parts of the world such as in Iran [25]. According to the researches, to produce 1 kg of corn's dry matter, 368 liters of water is needed, while this need for sorghum is 332 liters, for barley is 434 liters, and for wheat is 514 liters [8].

Superabsorbent polymers are made of hydrocarbon. These materials absorb and maintain water to 10 times more than their own weight, and as the environment dries out, the water inside the polymer starts to come out and therefore the soil will remain wet without any need of re-irrigation [13, 21, 25].The application of superabsorbent polymers on farms, increases the water conservation in soil, decreases water consumption, and prevent the fertilizer from being washed away by irrigation water [17, 6].

Corn plant, like many other crops, has the ability to decrease performance by increasing the retransfer of reserved materials to the maize during occurrence of different tensions like water shortages. The potential of this retransfer, which is favorable physiological index, depends on different factors such as genotype, density, and the water shortage tension intensity [22]. During the seed filling phase due to transfer of food to the seeds, an increase in growth intercepting hormones, an increase in ratio of abscisic acid to cytokinins in leaves, a decrease in leaf strength, an increase in the death of plant tissues, the falling of lower bush leaves, increasing respiration speed due to shadowing and reducing light, decreasing the accumulation of dry matter, and increasing the retransfer in plant are observed [1, 2, 7, 9, 23]. According to the current reports, the share of stored materials retransfer before flowering on corn seed performance in different conditions is between 0 to 90 percent and is reported to be 20 to 40 percents in average [22]. The results from Lak *et al*., [22] experiment on this subject show that the amount of dry matter retransfer is significantly affected by dry tension and the maximum amount of transfer was related to mild aridity treatment with 164.42 g. The objective of this paper was to examine whether the superabsorbent is able to increase the performance during dry tensions by supplying some part of plant's water and food requirements.

MATERIALS AND METHODS

This study was conducted in summer of 2009 on the experimental farm of Birjand Azad Islamic University (57° 46' to 60° 57' eastern longitude and 30° 35' to 34° 14' northern latitude, the average rainfall in hot and cold seasons 0.1 ml and 95.1 ml, respectively; with warm and dry weather located at east of Iran), with split plots experiment design as a complete random block with three replications. The irrigation treatment was considered in three levels (40, 70, and 100 percent need of irrigation) as the main plot and amounts of superabsorbent in four levels (0, 35, 75, and 105 kg/ha) as ancillary plots. The properties of superabsorbent are presented in table 1. The plant's water requirements were determined based on FAO method and by applying the pan evaporation data [15].

Table 1: The A200 superabsorbent material properties

Colour	White
Particle size	30-100 µm
Moisture content	3-5%
Density	1.4-1.5 g/cm^3
Acidity	6-7
Minimum soluble particle (weight percentage)	1-2
Practical absorption of 0.9% sodium chloride salt solution	45 g/g
Practical absorption of city water	190-550 g/g
Practical absorption of distilled water	220-660 g/g

At the time of physiological maturity of seeds, this is determined with the formation of a black layer at the basis of the seed, the final harvest is performed. During the final harvest, 15 bushes were cut from soil from the middle section of each plot and the total weight of the maize, seeds weight, seed performance, number of rows and number of seeds in each row, weight of 1000 seeds, stem diameter, and harvest index were determined. In order to determine the weight of 1000 seeds, 5 samples of each containing 1000 seeds were randomly selected from the separated seeds from maize and weighed. To determine the amount of efficiency and retransfer share of photosynthetic materials on seed performance the following equation was applied [22]:

Remobilization amount (g/m^2) = dry weight of growth organs during tasseling stage (g/m^2) – dry weight of growth organs during maturity (g/m^2)

Remobilization efficiency = retransfer amount (g/m^2) / dry weight of growth organs during tasseling stage (g/m^2)

Remobilization share on seed performance (percent) = [Remobilization amount (g/m^2) / seed performance (g/m^2)]*100

In order to determine the dry weight, harvested samples were held for 24h in an air conditioned oven at 75°C and weighed. The relative moisture content of the leaf one day prior to irrigation in corn leaf was measured during 8-9am [10, 11]. The chlorophyll index was measured using a chlorophyll meter (SPAD-502, KONICA MINOLTA) in three different parts of the leaf including beginning, middle, and end and in three bushes from each plot, and then the average amount for each plot was recorded [18]. Growing degree day (GDD) was calculated using equation (1):

$$GDD = \left(\frac{T_{\max} + T_{\min}}{2}\right) - B \qquad (1)$$

T_{max} and T_{min} are maximum and minimum daily temperatures, respectively, and B is the base temperature which is considered as 10°C [4]. The data were analyzed using SAS 9.1 and SPSS 14 software. The figures were also drawn using SPSS and Excel software. In order to compare the treatments averages, the Duncan method at level of 5% was applied.

RESULTS

The dry tension had a positive and significant effect on retransfer of photosynthetic materials (Table 1). The results show that the amounts of photosynthetic materials remobilization for favorable irrigation, medium dry tension, and intensive dry tension treatments were 57.88, 103.09, and 101.08 g/m^2, respectively, i.e. the amount of photosynthetic materials retransfer increased by 43.8% for medium dry tension and by 42.7% for intensive dry tension comparing to favorable irrigation treatment (Table 2). The dry tension had a positive and significant effect on remobilization efficiency of photosynthetic materials (Table 1). The remobilization efficiency of photosynthetic materials shows the ratio of remobilization dry matters to reserved dry matters, which under medium and intensive dry tensions, and favorable irrigation was 0.18, 0.13, and 0.05, respectively (Table 2).

The dry tension had a positive and significant effect on remobilization share of photosynthetic materials in seed performance (Table 1). The remobilization share of photosynthetic materials in seed performance, under intensive and medium dry tensions, and favorable irrigation was 17.66, 13.20, and 5.12 which showed that increasing the intensity of dry tension, increases the share of reserved photosynthetic materials in seed performance (Table 2).
The superabsorbent had a significant effect on remobilization amount of photosynthetic materials (Table 1). Remobilization amounts of photosynthetic materials in the main treatment with 35, 75, and 105 kg of superabsorbent per hectare, were 136.42, 74.38, 55.84, and 82.77 g/m^2, respectively, and there was a significant difference between the main treatments and other treatments (Table 4).

The superabsorbent decreased the remobilization share of photosynthetic materials in seed performance (Table 1). The remobilization shares of photosynthetic materials in seed performance for main treatment with 35, 75, and 105 kg of superabsorbent per hectare, were 20.34, 10.19, 7.98, and 9.47 percent, respectively (Table 4).

DISCUSSION

The dry tension causes a decrease in leaf area index and therefore in CGR (Table 2). Thus, the amount of dry matter accumulation in reserving organs and also the photosynthesis during the filling phase of seed is decreased and in order to supply the destination need, the plant uses the stored materials in stem and leaves. In this experiment, the retransfer amount of photosynthetic materials for favorable irrigation treatment was decreased compared to medium and intensive tensions due to high level of photosynthesis during filling phase of seed, which showed that increasing the leaf area and therefore increasing the growth speed of the product causes a decrease in retransfer amount of photosynthetic materials (Figure 1).

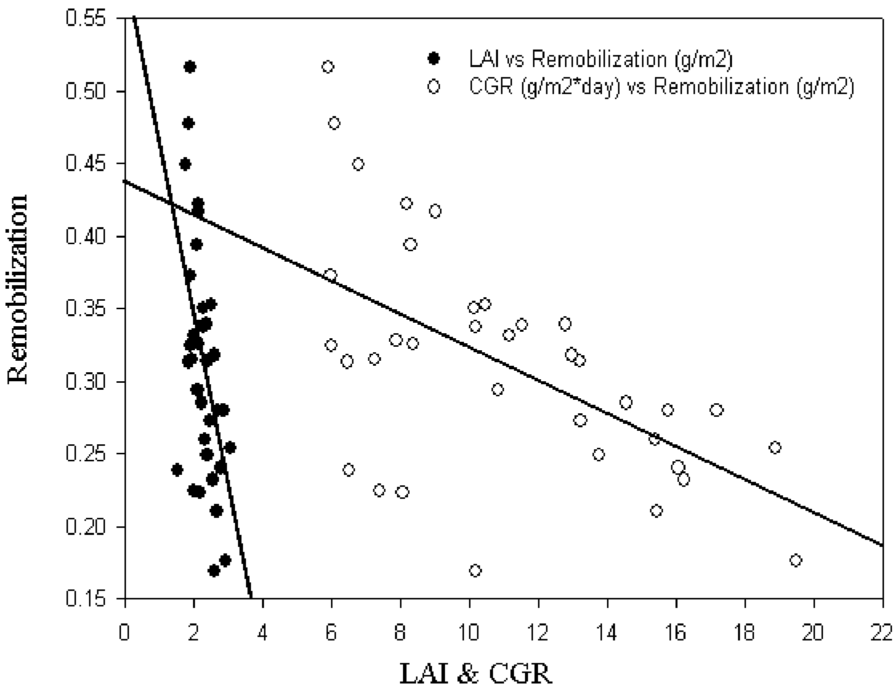

Figure 1. Moderate the relationship between LAI and CGR with the Remobilization

Table 1 – Results of variance analysis

Source	d.f	Re-transmission rate (g/m)	Remobilization efficiency	Contribution of remobilization in yield (%)	LAI in the peak week	CGR in the peak week
Block	2	268.36 ^{ns}	0.0006 ^{ns}	5.77 ^{ns}	0.13 ^{ns}	8.7 ^{ns}
Irrigation (A)	2	7827.48**	0.05**	484.94**	5.44**	1047.58**
Error (a)	4	47.62	0.00005	0.49	0.67	17.59
Superabsorbent (B)	3	10771.2**	0.029**	286.22**	0.69**	73.96**
A*B	6	1600.17 ^{ns}	0.004 ^{ns}	41.59 ^{ns}	0.18 ^{ns}	5.83 ^{ns}
Error (b)	18	1156.9	0.002	21.06	0.13	3.6
Coefficient of variation (%)		38.93	38.25	38.26	10.85	8.3

ns,not significant; * significant at 0.05 probability level; ** significant at 0.01 probability level.

Table 2 - Effect of different irrigation levels on re-transmit, re-transmission efficiency, the contribution of remobilization in yield and leaf area index and crop growth rate during the peak feeding on corn varieties 704

Traits / Water levels	Re-transmission Rate(g/m²)	Remobilization Efficiency	Contribution of remobilization in yield (%)	LAI in the peak week	CGR in the peak week
Optimal irrigation (100%)	57.88 ^{a}	0.05 ^{c}	5.12 ^{c}	4.08 ^{a}	32.43 ^{a}
Moderate stress (70%)	103.09 ^{a}	0.13 ^{b}	13.2 ^{b}	3.16 ^{ab}	22.38 ^{b}
Severe stress (40%)	101.08 ^{b}	0.18 ^{a}	17.66^{a}	2.77 ^{b}	13.76^{c}

Means followed by the same letter(s) in a column are ststistically non-significant at 5% level of probability.

Table 3: Pearson correlation coefficients between yield and some characteristicsIn testing the effect of different levels of water stress in corn varieties 704 and Superabsorben

Traits	1	2	3	4	5	6	7	8	9
Yield	1								
WUE	0.965**	1							
mean LAI during the growing season	0.860**	0.833**	1						
Average crop growth rate (during the growing season)	0.958**	0.899**	0 .902**	1					
Average shoot dry weight (during the growing season)	0.909**	0.888**	0.960**	0.964**	1				
Re-transmission	-0.465**	-0.439**	-0.458**	-0.452**	-0.523**	1			
Remobilization Efficiency	-0.696**	-0.689**	-0.632**	-0.703**	-0.746**	0.910**	1		
Contribution of remobilization in yield (%)	-0.484**	-0.585**	-0.36*	-0.456**	-0.484**	0.548**	0.721**	1	
Average chlorophyll (grain filling stage)	0.909**	0.876**	0.676**	0.923**	0.937**	-0.481**	-0.704**	-0.559**	1

* significant at 0.05 probability level; ** significant at 0.01 probability level.

Table 4 - Effect of different levels Superabsorben on this transfer, the efficiency of retransmission, the retransmission of the yield and leaf area index and crop growth rate during the peak feeding on corn varieties 704

Traits / Superabsorbent levels	Re-transmission Rate(g/m²)	Remobilization Efficiency	Contribution of remobilization in yield (%)	LAI in the peak week	CGR in the peak week
Control (lack of Superabsorben)	136.42 a	0.2 a	20.34 a	3.05 b	19.14 c
Superabsorben(35kg/h)	74.38 b	0.1 b	10.19 b	3.31 b	22.39 b
Superabsorben(75kg/h)	55.84 b	0.08 b	7.98 b	3.27 b	23.99b
Superabsorben(105kg/h)	82.77 b	0.09 b	9.47 b	3.72 a	25.91 a

Means followed by the same letter(s) in a column are ststistically non-significant at 5% level of probability.

There is a negative and significant correlation (r = -0.458) between leaf area index during growth season and retransfer amount of photosynthetic materials and also between the average crop growth speed during growth season and retransfer amount of photosynthetic materials (r = -0.452) (Table 3). These results and conclusions are similar to the reports of other researchers [5, 12, 19, 22]. Considering that the transferring of dry matters is carried out from both leaf and stem, therefore under dry tension the retransfer from leaves is increased and weakens the leaf. The dry tension during the filling phase of seed can lead to early death of leaves due to food transfer from leaves [24]. Chau and Bahargava [14] reported that the leaf area strength and dry matter accumulation after flowering phase have a positive and significant correlation with seed performance and by increasing photosynthetic activity in these phases, increases the dry matter accumulation and seed performance. Sharma-Natu and Ghildiyal [16] reported that the high growth rate of crop causes a decrease in retransfer of photosynthetic materials and consequently increases the leaf area strength. Probably, the superabsorbent increases the leaf area strength and current photosynthesis share and decreases the stored dry matters in seed production and therefore decreases the ratio of the transferred dry matter to stored dry matter. It appears that superabsorbent with its positive and significant effect on amount of stem's dry matter and current photosynthesis of plant was able to decrease the retransfer share of photosynthesis materials in seed performance and therefore significantly decreases the retransfer share of photosynthesis materials in seed performance. Goush and Singh [1] reported that there is a close and positive relationship between crop growth rate and leaf area index and seed performance. Besides, the maximum seed performance is companied with the equilibrium between start and destination, so that it would cause accumulation of dry matter in stems, not the depletion of dry matter from stems during the seed filling phase. Therefore, the increasing of stem weight and also decreasing the transfer amount of photosynthetic materials lead to an increase in seed performance. According to the positive and significant effect of superabsorbent on chlorophyll index, and the positive and the significant correlation ($r = 0.909$) of the average chlorophyll index during growth season with seed performance, it appears that the superabsorbent increases the duration of light usage and the current photosynthesis, and therefore by decreasing the retransfer from leaves and chlorophyll destruction, increases the leaf area strength that leads to higher seed performance. Figure (1) shows that increasing retransfer of photosynthesis materials causes a reduction in plant's chlorophyll index during the seed filling phase of the experiment. The leaf area strength from the beginning of ear shoot emergence to maturity phase could be the approximate representative of seed performance, because the leaf area strength in this stage has a close relation with photosynthetic and dry matter accumulation and is also a production index [3]. Brevedan and Egli [20] stated that during dry tension, increasing nitrogen transfer from leaves leads to chlorophyll content. Along with this conclusion, in this study, a negative and significant correlation ($r = -0.481$) was observed between retransfer amount of photosynthetic materials and average chlorophyll index during seed filling phase (Table 3).

By decreasing the relative moisture content due to dry tension, the porosities are closed and limit the CO_2 availability for plant which decreases the leaf chlorophyll index and light usage efficiency and the amount of photosynthesis. The low level of photosynthesis amount causes the maldevelopment leaf area and decreases dry matter accumulation per area unit. In total, these factors decrease the leaf area strength and pure photosynthesis amount during seed filling phase and consequently increase the retransfer amount of photosynthetic materials to seed. It seems that, under such conditions, the superabsorbent by positively affecting the chlorophyll index, leaf area index, and crop growth rate, causes an increase in photosynthetic materials accumulation in growth organs and also increase the leaf area strength during see filling phase, and therefore the superabsorbent has a negative effect on photosynthetic materials remobilization amount, efficiency and the share.

Acknowledgments
Thanks to the Faculty of Islamic Azad University, Parsabad Moghan, Iran.

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